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AGRICULTURAL MEMORANDUM NO 885

A Severe Gale in the South West of England during December 1979 by I BARRIE and B INGHAM

Introduction

The south-west of England experienced some remarkable weather in the form of severe gales and heavy rainfall during December 1979.

As a result much damage was caused to agricultural buildings and equipment; but just how exceptional the weather was in relation to previous occurrences was not clear.

In this memorandum the wind speeds and rainfall are examined and compared to historical data from a few meteorological sites, with special reference to sustained strong winds over a period of six hours.

Synoptic Situation

An area of low pressure, low G, formed at 52°N, 47°W in a northerly airstream with a strong westerly thermal flow above. At 1200 GMT on the 13 December the low had a central pressure of 992 mb. The depression moved at 50 knots to be centred at $52\frac{1}{2}$°N, 18°W by 1200 GMT on the 14th with the central pressure down to 972 mb.

It continued on an eastward track, deepening to 964 mb by 1800 GMT before moving to the north-east and filling.

By 1200 GMT on the 15th, low G had moved to 55°N, 2°E and had a central pressure of 972 mb (fig 1) (Met Office, 1979).

At the time of the strongest west to north-west winds, 00-1200 GMT, the main frontal system had cleared the area but an occlusion trailing back from the low pressure centre was moving rapidly southwards towards Cornwall and Devon.

Windspeeds during 15 December 1979

The anemograph records from seventeen stations (fig 2) were examined and the following data extracted:

the maximum hourly mean wind speed*
the maximum gust*
the maximum mean wind speed over a six hour period
the mean speed for the day
the mean speed for the month
the number of days in the month on which gale force winds were recorded (table 1)

* NOTE All the hourly windspeeds and gusts quoted are averages taken over the whole hour at the 1978 effective height of the anemometer (see table 1). If there has been a change of effective height during the period the data has been adjusted to the 1978 effective height using

$$Vh = Vz\left(\frac{h}{z}\right)^{0.17} \quad \text{for hourly mean winds}$$

$$Vh = Vz\left(\frac{h}{z}\right)^{0.085} \quad \text{for gust speeds}$$

where Vh = speed at new effective height, h
Vh = " " old " " , z.

Unfortunately some of the anemograph records were incomplete or defective, especially from the coastguard stations where more urgent tasks obviously took priority.

From table 1 it is evident that the strongest winds were recorded around the south-west tip of Cornwall and along the south coast, with the hourly mean wind speeds in the region of 60 knots and gusting to around 100 knots at the more exposed sites. Representative values for the less exposed areas were about 50 knots, gusting 80 knots and further in land towards Somerset, North Devon and Wiltshire the strength of the winds decreased considerably to 30-35 knots, gusting to almost 60 knots.

The hourly mean speeds and gusts were very high, even reaching Beaufort force 12 at Lizard, but a more unusual feature of the gales was the period over which the very strong winds were sustained.

Most noteworthy in this respect was St Mawgan where, during a 12 hour period commencing at 0200 GMT, the mean hourly wind speed did not fall below 40 knots (21 m/s). Similarly at Mountbatten the lowest hourly mean speed recorded between 2300 GMT on the 14th to the 15th at 1000 GMT was 39 knots.

Even with the winds abating by late evening, such was the earlier strength that many of the sites had an average speed during the twenty four hour period ending at midnight, in excess of 34 knots.

The gale of 15th December 1979 compared to recent gales

The daily mean speeds were compared to archived data and it was found that the daily mean of 32.4 knots at Mountbatten has only been exceeded three times between 1958 and 1978; (32.7 kts on 18/12/65: 34.4 kts on 5/12/72: 34.1 kts on 16/1/74). The daily mean speed of 38.2 knots recorded at St Mawgan is higher than any other between 1967 and 1978.

The month overall also proved to be much more windy that average with the monthly mean speed of 16.9 knots at Mountbatten only once being exceeded since 1958; that was during January 1974 when 19.3 knots was recorded. The monthly mean speed of 16.7 knots during December 1979 at St Mawgan was the highest between 1967 and 1978 excepting two occasions; January 1974 (18.2 knots)and December 1974 (18.1 knots).

Clearly the winds speeds of December 1979 were considerably above average with the only comparable gale which affected this part of the country during the past twenty years occurring on the already noted 16th January 1974.

This north-westerly gale, although affecting a larger area, produced wind speeds only occasionally in excess of those during December 1979 in the south-west (table 2).

Comparable records of hourly mean wind speeds were analysed over the six consecutive hours covering the period of the strongest winds for the following stations and years, table 3.

TABLE 3. Maximum wind speeds recorded over a 6 hour period.

	Mean windspeed over 6 hours (knots)	Date
St Mawgan (1971-78)	42.0	16.1.74
Mountbatten (1959-78)	47.8	16.1.74
Exeter (1971-78)	34.2	14.1.77
Boscombe (1957-78)	42.2	27.3.66

These values are less than those for December 1979 at St Mawgan and Exeter, virtually the same at Mountbatten, but considerably greater at Boscombe. Other stations analysed during the investigation have been noted in table 5 and are for information only.

A longer period analysis of extreme windspeed

Some longer period maximum hourly wind speeds are given by Hardman, Helliwell and Hopkins (1972) for anemometer stations throughout the UK.

From this data table 4 was compiled with the more recent maximum included where possible.

This table shows that, when compared to table 1, the windspeeds recorded during December 1979 over the Cornwall and South-west Devon area were in excess of the previous maxima even when the records extend back to 1921.

A possible exception was the gales during December 1929 when the maximum hourly winds recorded at Scilly on consecutive days between the 4th and 9th were 180° 46 kts (gusting 69 kts); 190° 48 (69); 260° 57 (95); 280° 58 (88); 290 53 (81); 240° 47 (69).

Two other sites, Plymouth Hoe and Pendennis Castle, were open during December 1929 and recorded maximum hourly means of 56 and 60 knots respectively. These stations have long since closed so no direct comparisons of windspeeds can be made.

Return periods of windspeeds

For a few stations the return periods for the maximum mean hourly windspeeds and gusts have been included in table 1.

These return periods have been calculated (Collingbourne, personal communication) using a technique derived by Lieblein (1974), and although statistically sound should be treated with caution.

Primarily this is because of the relatively short period over which recorded data is available and secondly, even when a 40 year record exists a different statistical method will lead to quite different return periods. Additionally a couple of knots either way leads to a radically different return period.

The periods over which the data was analysed is similar to the periods quoted in table 4. The more recent data from 1972 to 1978 was included.

Even accepting the above, the return period of 257 years for a gust speed of 83 knots at St Mawgan is most noteworthy. Lesser return periods of 50-75 years have also been calculated for winds at Scilly and Lizard.

The Extent and Nature of the Damage

A. Damage to Trees.

A gale during December will affect coniferous trees to a much greater extent than deciduous trees due to the much higher drag coefficient caused by the presence of dense foliage.

The two major types of damage to trees, uprooting and stem-snap (collectively termed "windthrow") occurs most often on poorly drained soils and freely drained soils respectively (Fraser, et.al.; 1967). On this particular occasion uprooting was the predominant type of windthrow.

The region most severely affected by the gales is not heavily forested so there were no reports of large scale damage to plantations but rather isolated incidents having a "nuisance" value, where telephone lines were broken, a road blocked or a structure damaged.

The circumstances likely to result in windthrow were examined with reference to two articles detailing destructive gales (Fraser, 1971; Oliver and Mayhead, 1974).

Fraser describes a gale which affected a large area of Central Scotland during January 1968 and produced mean hourly windspeeds of 62 knots, gusting to 89 knots at Edinburgh (Turnhouse) and 53 knots, gusting to 89 knots at Abbotsinch. Some 1,641,000 cubic metres of timber was windthrown over the area with spruce and pine being the main casualties.

Oliver et.al. published detailed wind velocity measurements at several levels within Thetford Forest during the 2nd April 1973. The maximum hourly windspeeds recorded at two nearby anemograph stations, Honington (35 kt) and Marham (37 kt), were not exceptionally strong but were still enough to result in 15 trees being uprooted within 150 m radius of the anemometer tower in the forest.

The gale which affected Cornwall during December had windspeeds in between the examples given above.

It is difficult to specify the strength of wind necessary to uproot a tree but a deflection of the trunk of 7° in sandy soil, 10° in brown earth and 25° in a peaty gley are the quoted critical values. Most of the work done in relating tree deflection to windstrength considers the static case where a tree is pulled over and the force applied to the tree noted. Such tree-pulling exercises indicate that for a 50 foot Sitka Spruce on a peaty gley a steady wind speed of 39 knots is necessary.

Trees experience windthrow at much lower velocities than the values derived from tree-pulling studies. The most plausible explanation for the discrepancy is the effect of gust frequencies on the natural resonance of the tree. This phenomena has been termed the "Honami" effect (Inoue, 1955, 1979). The critical gust frequency is around 3 seconds, depending on the soil type and rooting depth. If the gust frequency over the forest canopy coincides with the natural resonance of the tree, considerable damage could result at much lower windspeeds than would otherwise appear possible.

In this respect isolated trees are at a much greater risk than a well managed forest where the top of the canopy provides a uniform surface enabling much of the wind's energy to be absorbed by the tree tops.

B. Damage to glass and plastic structures.

Reports of extensive damage throughout Cornwall and South-west Devon have been received by the ADAS regional office at Bristol. There are numerous instances of glass-houses where the damage varied from doors being ripped off - ventilation gear buckling up - to the whole structure being completely destroyed. The subsequent damage to tomato, carnation, pot plants etc was such than many crops had to be entirely replaced.

In the worst hit areas most of the polythene structures experienced some damage ranging from complete destruction to secondary damage caused by flying glass or other debris.

A significant contribution to the extent of the damage was made by either poorly fitting or improperly closed doors. The vibrations caused by the wind soon shook open unsecured doors leading to whole sections of glass-houses being blown out.

Rainfall during December 1979

A contributary factor to the scale of the damage caused to trees by the wind was the above average rainfall experienced during the month.

The first week of December was reasonably dry in the south-west, but between the 8th and 15th quite large falls were recorded, particularly on the 8th, 9th, 13th and 14th (table 6).

With the soil already at field capacity that portion of the rainfall not accounted for by surface run-off produced some water-logging of the soil.

The process whereby the soil around the root plate of a swaying tree is slackened and washed out when the soil is saturated is vividly described by Hutte (1968).

The earlier gale on the 11th December possibly had a loosening-up effect on many trees which were subsequently uprooted by further strong winds and heavy rain on the 15th and again on the 27th December (table 7).

Concluding Remarks

The gale on the 15th December could be classified as being exceptional, but only over a fairly limited area of land. Within this area, widespread and frequently substantial damage was caused to most types of buildings and many trees.

The recurring gales and very heavy rain throughout the month together with the prolonged strength of the winds during the 15th undoubtedly acted together to produce greater damage than would have been expected had the gale of the 15th occurred in isolation of the other factors.

Met O 8a
April 1980

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FIG 1.

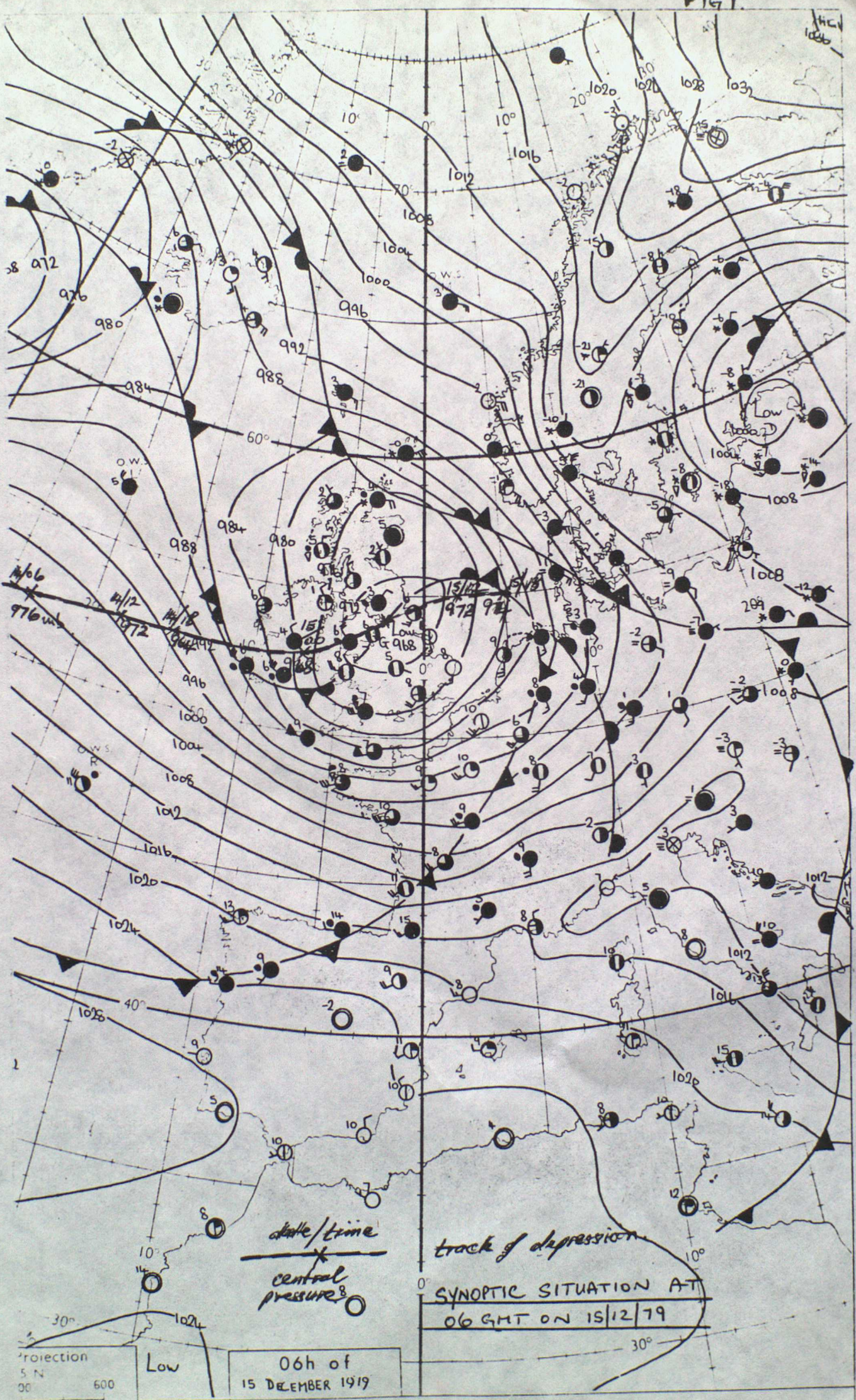
date/time
central pressure
track of depression
SYNOPTIC SITUATION AT
06 GMT ON 15/12/79
06h of
15 DECEMBER 1979
Low
Projection
Mercator
600
Low
968
972
976
980
984
988
992
996
1000
1004
1008
1012
1016
1020
1024
1028
1032
1036
10°
20°
30°
40°
50°
60°
70°
80°

FIG. 2

MEAN WIND SPEEDS (KNOTS) OVER A 6 HOUR PERIOD — 15/12/79

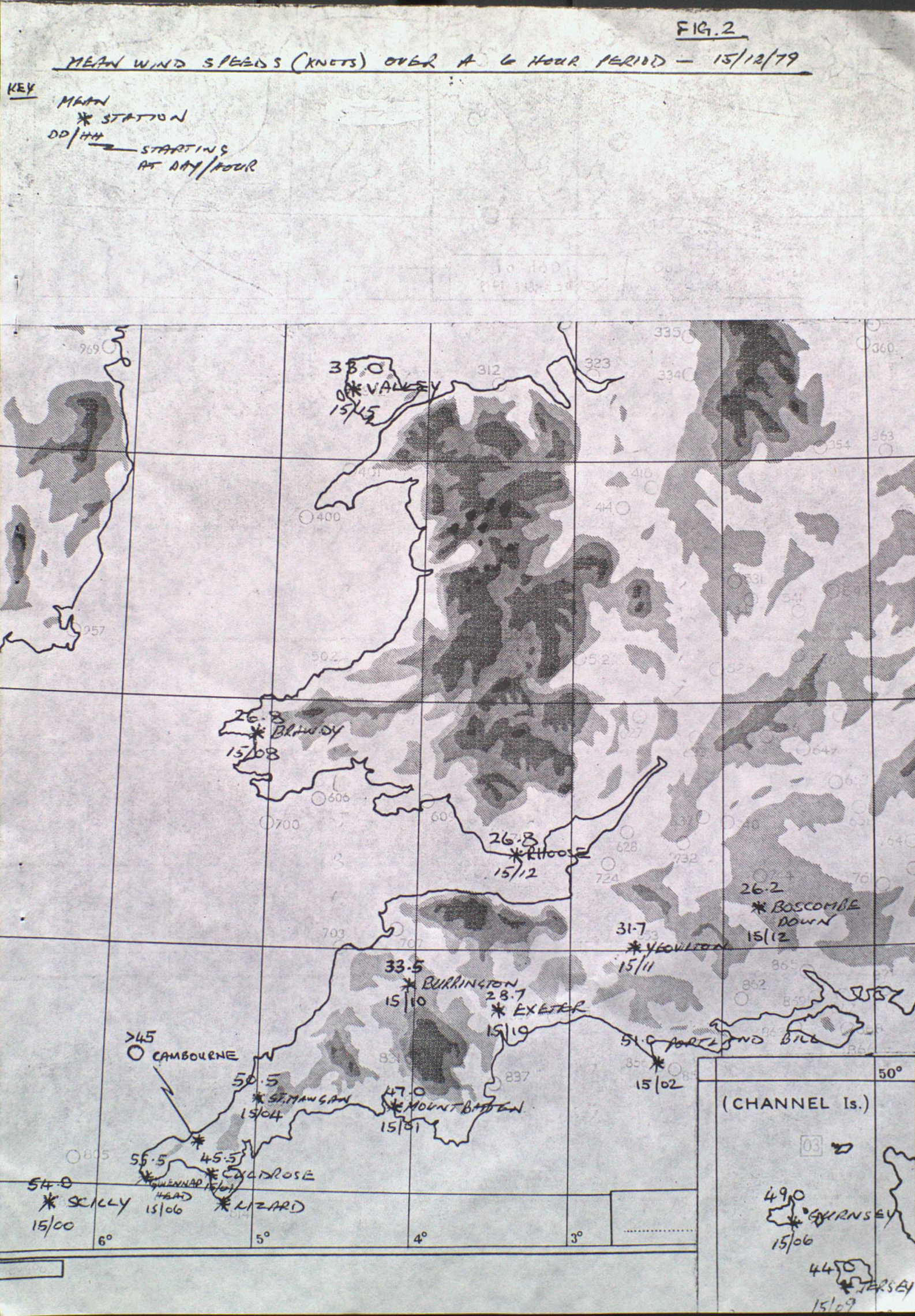

TABLE 1 WIND DATA FOR THE 15TH DECEMBER 1979

STATION	ANEMOMETER HEIGHT (M) ACTUAL	EFFECTIVE	MAX HOURLY MEAN (KTS)	RETURN PERIOD (YRS)	MAX GUST (KTS)	RETURN PERIOD (YRS)	MEAN OVER 6 HOURS	MEAN FOR DAY	MEAN FOR MONTH	NO OF DAYS WITH GALE
ST MAWGAN	13	13	52	67	83	257	50.5	38.2	16.7	8
MOUNTBATTEN	13	13	50	9	75	11	47.0	32.4	16.9	6
EXETER/	12	-	32	-	58	-	28.7	24.7	11.4	2
JERSEY	12	10	46	2	71	2	44.0	37.0	16.1	5
SCILLY	20	17	60	15	99	71	54.0	41.4	18.4	6
PORTLAND BILL*	13	13	54	-	78	-	51.0	45.7	22.2	14
GWENNAP HEAD/	10	-	60	-	103	-	55.5	43.4	20.6	11
LIZARD*	23	18	66	54	91	28	-	40.0	23.5	15
VALLEY	16	12	35	-	56	-	33.0	27.9	19.1	13
BOSCOMBE DOWN	17	17	28	1	47	1	26.2	23.4	13.3	1
GUERNSEY	11	10	54	-	83	-	49.0	41.5	18.6	9
BRAWDY	10	10	30	-	49	-	26.8	22.4	15.2	-
RHOOSE	10	10	28	-	46	-	26.8	23.9	12.5	-
YEOVILTON	12	10	35	-	57	-	31.7	24.3	12.9	3
CULDROSE*	15	-	49	-	77	-	45.5	33.7	15.9	6
CAMBOURNE*	10	10	50	-	81	-	>45	32.3	16.1	5
BURRINGTON	10	10	36	-	61	-	33.5	27.8	14.9	4

* defective record

/ poorly exposed site

TABLE 2 DATA FOR 16TH JANUARY 1974

	MAX HOURLY MEAN	MAX GUST	MAX MEAN (6 HRS)	MEAN FOR DAY	MEAN FOR MONTH	NO OF DAYS OF GALE IN MONTH
St Mawgan	46	65	42.0	33.1	18.3	8
Mountbatten	52	74	47.8	34.1	19.3	15
Exeter	35	56	31.0	22.7	10.9	2
Jersey	43	71	40.2	27.8	14.0	2
Scilly	49	82	47.0	35.6	19.3	9
Portland	48	69	44.3	33.7	19.4	9
Gwennap	57	80	48.9	38.0	23.4	17
Lizard	52	74	50.3	39.1	23.7	16
Valley	37	60	33.6	23.3	23.3	13
Boscombe	41	65	38.2	28.3	14.9	4

TABLE 4 EXTREME WIND SPEEDS

STATION/PERIOD	ANEMOMETER HEIGHT ACTUAL (M)	EFFECTIVE (M)	MAX HOURLY MEAN (KNOTS)	DATE	MAX GUST (KNOTS)	DATE
BOSCOMBE DOWN 1933-1978	17	17	47	1/43	80	3/47
VALLEY 1952-1978	16	12	56	12/66	84	1/65
PORTLAND BILL (LIGHTHOUSE) 1963-1968	47	47	64	10/67	89	1/66
PORTLAND BILL (COASTGUARD) 1969-1978	13	13	51	10/76	73	11/69
PLYMOUTH HOE 1921-43, 47-48, 50-65	27	20	56	12/29	84	3/22
MOUNTBATTEN 1965-1978	13	13	52	1/74	68	1/65
SCILLY 1921-1978	20	17	60	9/46, 11/54	95	12/29
LIZARD 1935-42, 45-47, 49-78	23	18	64	11/54	85	11/54
ST MAWGAN 1967-1978	13	13	47	1/75	62	11/69
JERSEY 1958-1971	12	10	68	10/64	93	10/64
EXETER 1970-1978	12	-/1	36	1/76, 10/76, 11/77, 2/78	59	11/77, 12/77, 12/78

/1 poorly exposed site

TABLE 5

MEAN WINDS OVER 6 HOURS	Kts	Date
Mildenhall (49-69)	36.8	16/12/62
Honington (70-78)	40.7	2/1/76
Marham (71-78)	40.8	2/1/76
Abbotsinch (5/66-78)	46.2	15/1/68
Leuchars (71-78)	43.5	12/1/74
Prestwick (57-78)	44.2	15/1/68
Turnhouse (62-78)	53.5	15/1/68
St Mawgan (71-78)	42.0	16/1/74
Mountbatten (59-78)	47.8	16/1/74
Valley (57-78)	52.8	1/12/66
Exeter (71-78)	34.2	14/1/77
Boscombe (57-78)	42.2	27/3/66
Elmdon (61-78)	36.5	16/2/62 and 2/1/76
Heathrow (5/59-78)	33.2	27/3/66
Ringway (49-78)	37.2	30/11/54

DAILY RAINFALL (MM): 8TH TO 15TH DECEMBER 1979 TABLE 6

	8	9	10	11	12	13	14	15	TOTAL
EXETER	0.5	9.1	3.4	0.5	7.4	12.3	10.3	2.4	45.9
HAWKRIDGE	16.6	19.7	17.6	1.7	6.5	16.6	15.6	9.2	103.5
HEMYOCK	6.2	14.3	7.3	-	11.2	14.4	14.0	3.2	70.6
STARCROSS	4.3	10.3	5.3	-	9.0	16.4	25.6	4.8	75.7
TORQUAY	14.2	12.0	6.4	0.1	9.4	17.6	18.8	4.3	82.8
PRINCETOWN	23.0	26.0	16.8	5.6	23.6	18.4	34.6	11.5	159.5
TOTNESS	27.9	19.3	9.9	0.1	13.2	19.6	31.3	4.7	126.0
SLAPTON	13.2	9.9	6.8	0.7	15.3	22.4	30.1	4.7	103.1
MOUNTBATTEN	15.5	13.8	4.8	4.6	6.7	14.9	20.4	6.8	87.5
ST JOHNS	14.4	19.0	11.5	5.7	13.5	12.5	25.1	9.6	111.3
BASTREET	22.2	26.2	20.5	8.4	19.5	12.6	28.4	16.6	154.4
LADOCK	9.6	10.2	5.6	5.8	6.0	9.7	27.6	4.2	78.7
CULDROSE	9.8	5.2	5.7	4.8	3.1	10.3	21.7	16.7	77.3
LIZARD	12.5	3.8	4.7	4.8	3.1	7.2	17.6	11.4	65.1
PENZANCE	13.8	5.7	8.3	2.2	5.8	7.3	31.1	11.1	85.3
SCILLY	7.6	4.2	1.2	1.3	3.1	9.7	11.9	9.9	48.9
ST MAWGAN	11.3	14.1	6.6	2.8	6.0	11.8	13.7	8.9	75.2
CONSTANTINE B	10.9	13.2	8.2	2.2	3.3	10.5	14.8	7.1	70.2
PENGELLY	16.3	16.8	7.5	8.8	8.1	15.2	17.5	6.6	96.8
HARTLAND PT	9.8	7.9	6.2	-	9.3	14.5	6.4	2.4	56.5
OKEHAMPTON	12.5	22.9	12.4	1.3	17.3	13.3	24.6	4.7	109.0
MELBURY	19.1	26.7	9.8	0.5	12.1	15.1	16.8	5.2	105.3

PERIOD TOTALS AND AVERAGES OF RAINFALL (MM) FOR DECEMBER

TABLE 7

STATION	ALTITUDE (M)	RAINFALL TOTALS (MM) 8-15	1-31	AVERAGE	% OF AVERAGE
EXETER	32	45.9	132.9	81	164
HAWKRIDGE	314	103.5	346.5	184	188
HEMYOCK	165	70.6	167.0	116	144
STARCROSS	9	75.7	174.1	85	205
TORQUAY	8	82.8	193.2	99	195
PRINCETOWN	394	159.5	432.9	219	198
TOTNESS	84	126.0	260.8	127	205
SLAPTON	32	103.1	183.5	119	154
MOUNTBATTEN	27	87.5	185.4	110	169
ST JOHNS	128	111.3	288.9	133	217
BASTREET	233	154.4	366.5	192	191
LADOCK	30	78.7	210.7	131	161
CULDROSE	81	77.3	171.8	111	155
LIZARD	73	65.1	140.6	103	137
PENZANCE	19	85.3	215.8	130	166
SCILLY	51	48.9	138.0	100	138
ST MAWGAN	103	75.2	175.8	119	148
CONSTANTINE B	36	70.2	155.2	102	152
PENGELLY	201	96.8	220.7	134	165
HARTLAND PT	93	56.5	122.1	94	130
OKEHAMPTON	372	109.0	301.3	180	167
MELBURY	143	105.3	249.9	150	167